AMMONIA PERMITS AND LAGOONS

First Nations Communities and the Options Available for Beating Nutrient Limits

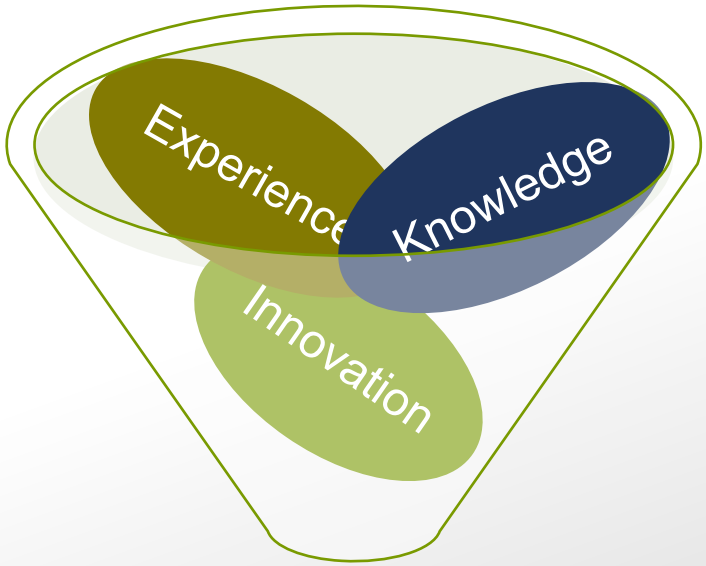
Workshop #18

Francis Bordeleau, Eng.

Nexom™

About Nexom

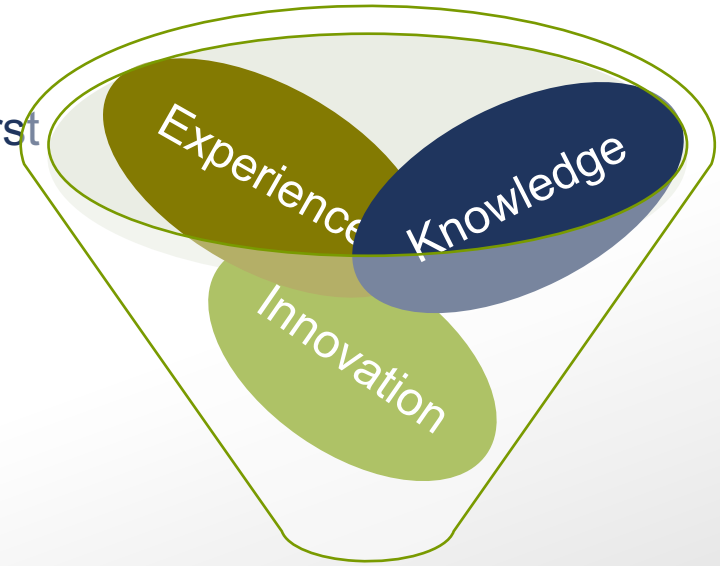
- **Founded** in Winnipeg in 1997
- **70 employees** in Canada and USA
- **More than 450 projects** in North America
- Experts in **nutrient removal**
- **Biological processes** (lagoons, SAGR, MBBR) and **filtration** (sand, cloth, belt)



About Nexom

Nexom is a preferred partner of ISC in Manitoba:

- **We understand** the challenges that First Nations communities face.
- Our systems are **simple**, **efficient**, **affordable**.
- Produce effluent of **better quality** than many mechanical plants.
- Quality and prices are **consistent**.
- Support for operators and *circuit riders* for the entire **life of the system.**



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Time to earn your CEUs ...

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What is Wastewater?

- Any **water** that has been **affected by human use** (domestic, industrial, commercial or agricultural), surface runoff or stormwater, plus any sewer inflow or infiltration.
- Municipal wastewater is mainly comprised of water (99.9%) with small concentrations of **suspended** and **dissolved**, **organic** and **inorganic** substances.

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What is Wastewater?

- Among the **organic substances** present in sewage are **carbohydrates**, **fats**, **proteins**, soaps, detergents, lignins, plastics and **pharmaceutical** products.
- Municipal wastewater also contains **inorganic substances** from domestic and industrial sources, including potentially toxic elements such as **ammonia**, arsenic and metals (cadmium, chromium, copper, lead, mercury, zinc, etc.)

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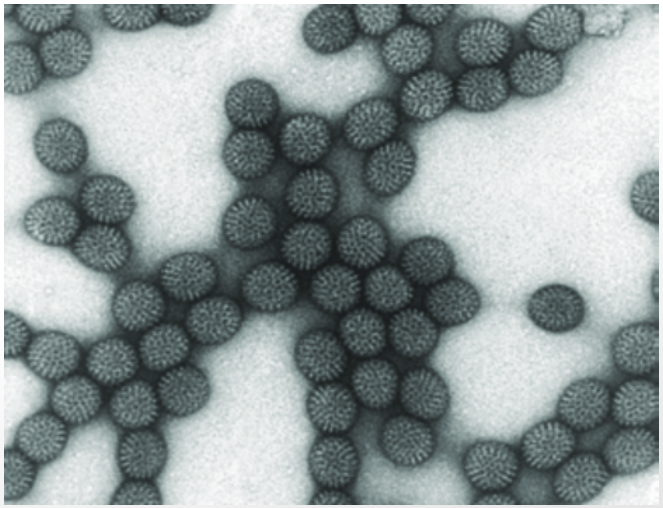
What is Wastewater?

- Finally, **pathogenic microbes** (viruses, bacteria, protozoa and helminths) may be present in raw municipal wastewater.



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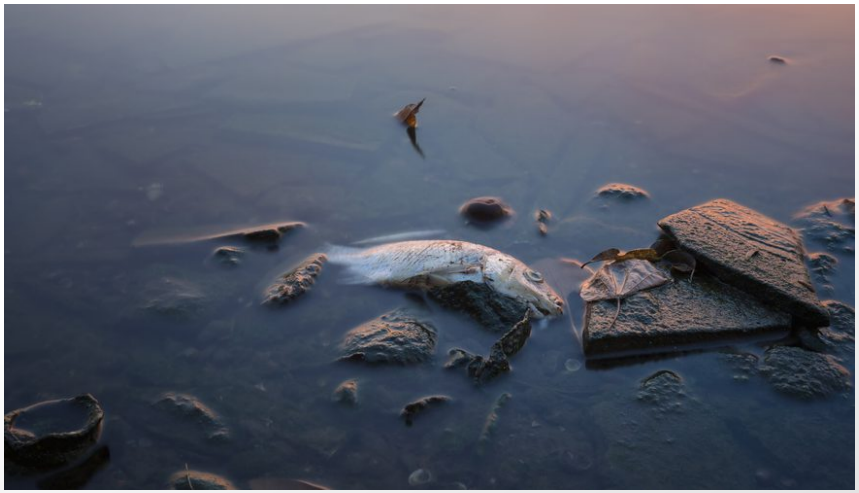
What are Nutrients?

- Elements that are **essential for life**
- In the context of **wastewater** treatment, two nutriments of interest are **nitrogen** (N) and **phosphorus** (P)
- Phosphorus is the limiting nutrient for **algal blooms** (eutrophication)
- Nitrogen (ammonia) can cause **toxicity** and kill fish



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What is Eutrophication?

The enrichment of surface waters with plant nutrients causing:

- Increase in **production** of phytoplankton, algae and macrophytes.
- **Replacement of desirable fish** by less desirable species.
- Production of **toxins** by certain algae (dogs have died)
- **Taste** and **odour** problems in water.
- Increasing operating **expenses** of public water supplies
- **Deoxygenation** of water resulting in **fish kills**.
- **Loss of recreational use** of water due to slime, weed infestation and noxious odor from decaying algae.
- **Economic loss** due to change in fish species, fish kills, etc.

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Why treat Wastewater?

- **Maintain** water quality and beauty
- **Allow normal use** of water and **activities** related to water
- **Protect life** (human, animal and plant)

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How to treat Wastewater?

- **Physical** (settling, screening, filtration)
- **Chemical** (precipitation, oxidation)
- **Radiation** (heat, UV)
- **Biological** (bacteria, protozoa, fungi, algae)
    - Land application (1800s) : cholera and thyphoid outbreaks
    - Biological filtration (UK, 1893)
    - Oxidation ponds (Germany, 1898)
    - Activated sludge (UK, 1914)

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Types of bugs in lagoons

- **Bacteria**, protozoa, fungi, algae
- **Aerobic**, anaerobic, facultative
- **Heterotrophic**, **autotrophic**

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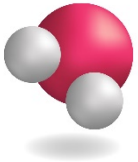
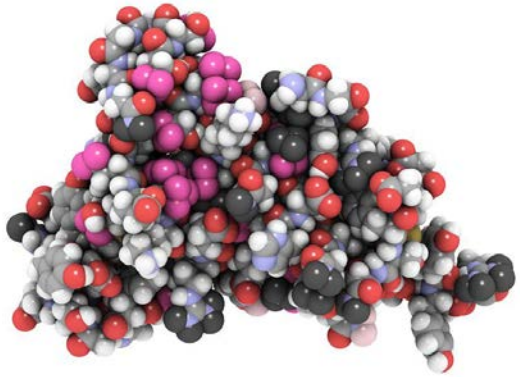
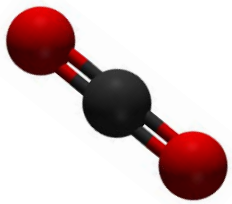
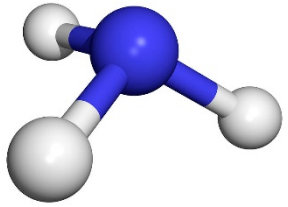


How bugs grow





- **Water** (H_2O) (*medium*)
- **Oxygen** (O_2)
- **Food**
  - Heterotrophs: **organic molecules** (C,H,O,N,P,S)
  - Autotrophs: **inorganic molecules** (CO_2, NH_4, PO_4)
- **Enzymes** (*knives*)
- **pH**
- **Temperature**
- **Time** (volume of lagoon ÷ flowrate)



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Regulations

About the WSER

WSER is a Canadian regulation that applies to **municipal wastewater systems** and wastewater systems **under federal government operation** and **on federal and Aboriginal land** that meet the following requirements:

- are designed to collect an **average daily volume of 100 m³ or more** of influent;

- and **deposit effluent that contains** at least one of the prescribed deleterious substances (**cBOD, TSS, chlorine, non ionized ammonia**), to **any water frequented by fish** or a place referred to in subsection 36(3)1 of the *Fisheries Act.*

For the purpose of WSER, a wastewater system is any work or site used for the collection and deposit of wastewater, whether or not the wastewater is treated. This definition includes both mechanical systems and lagoons.

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About the WSER

Effuent requirements:

- Not acutely lethal
- Average TSS not exceeding 25 mg/L
- Average cBOD not exceeding 25 mg/L
- Average total residual chlorine not exceeding 0.02 mg/L
- Maximum un-ionized ammonia (NH_3-N) less than 1.25 mg/L *

Acutely lethal means that the effluent at 100% concentration kills, during a 96-hour period, more than 50% of the rainbow trout subjected to it.

* Generally, this requirement is irrelevant because it is incompatible with the non lethality requirement.

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Treatment Options

optAER®

Lagoons

BOD_5

SAGR

Nitrification

NH_4^+ / NH_3

BluePRO®

Filtration

Phosphorus / Metals

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OPTAER®

Lagoons

Fine bubble diffusers

- Add oxygen to the water
- Very energy efficient

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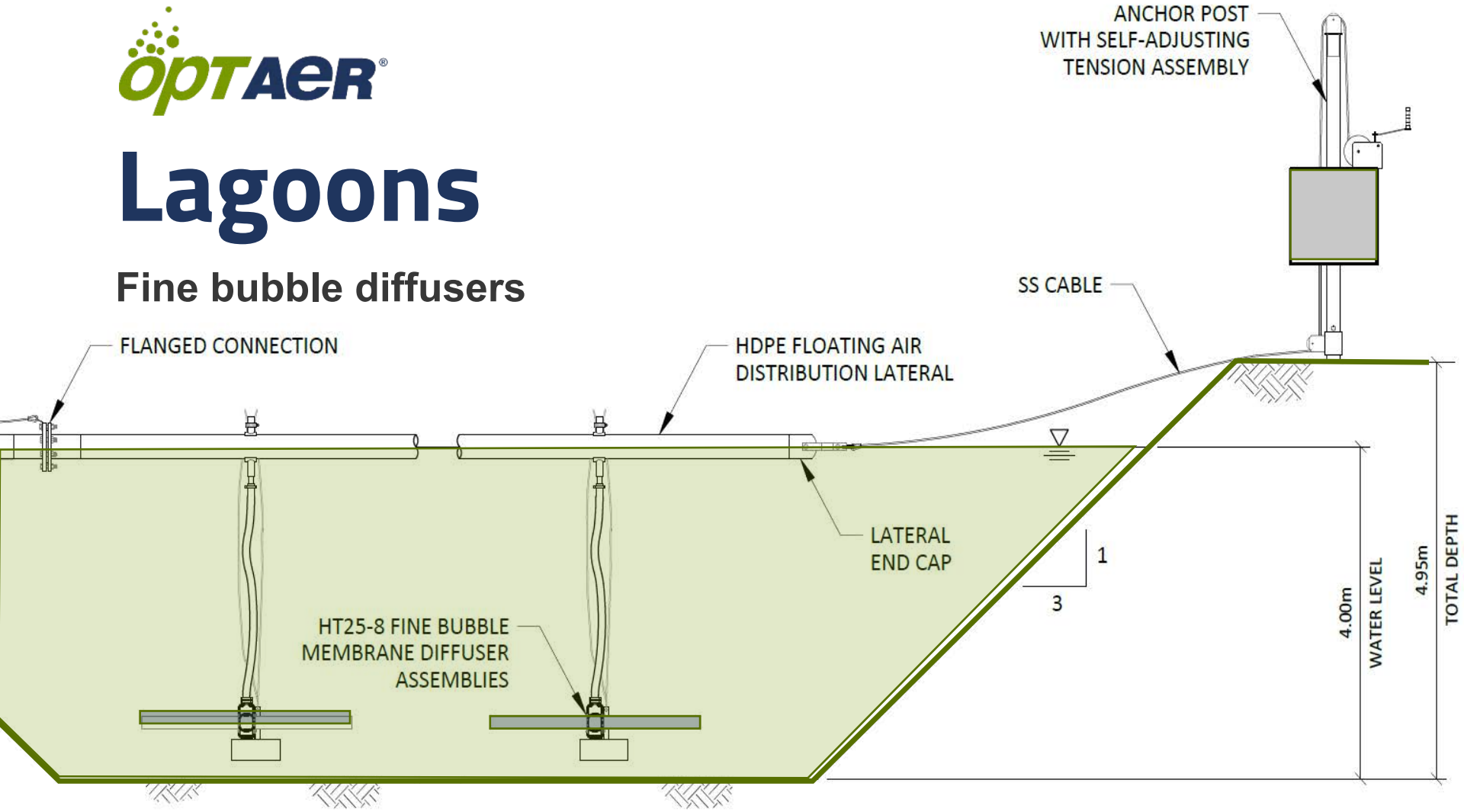
Lagoons

Fine bubble diffusers



OPTAER®

Lagoons

Fine bubble diffusers

- Pre-assembled
- Easy to install / No leak

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OPTAER®

Lagoons

Fine bubble diffusers

- Self-tensioning device

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OPTAER®

Lagoons

Fine bubble diffusers

- Light / Easy to lift
- Open ends / Easy to clean

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OPTAER®

Lagoons

Fine bubble diffusers

- 2X more efficient than coarse bubble diffusers
- Floating / No need to drain

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OPTAER®

Lagoons

Air blowers

- Selected by Nexom

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Lagoons

Baffles

- Create multiple zones (aerated or not)
- Prevent short circuiting
- Increase retention time
- Nitrification generally occurs in summer only

Treatment Options

optAER®

Lagoons

BOD_5

SAGR

Nitrification

NH_4^+ / NH_3

BluePRO®

Filtration

Phosphorus / Metals

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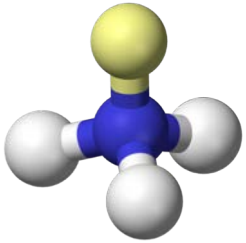
Why remove ammonia?



Ammonium NH_4^+
+ Un-ionized Ammonia NH_3

Total Ammonia

NH_3 < 0.2 mg/L is considered non lethal

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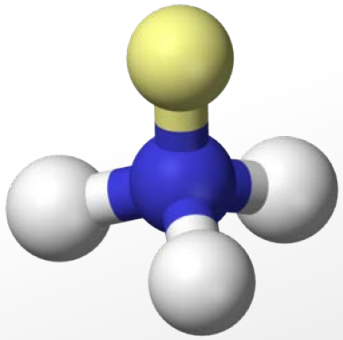
Percent NH_3 in Total ammonia

Temp. (°C)	pH →								
	6,0	6,5	7,0	7,5	8,0	8,5	9,0	9,5	10,0
0	0,008	0,026	0,082	0,261	0,820	8,55	7,64	20,7	45,3
5	0,012	0,039	0,125	0,394	1,23	3,80	11,1	28,3	55,6
10	0,018	0,058	0,186	0,586	1,83	5,56	15,7	37,1	65,1
15	0,027	0,086	0,273	0,859	2,67	7,97	21,5	46,4	73,3
20	0,039	0,125	0,396	1,24	3,82	11,2	28,4	55,7	79,9
25	0,056	0,180	0,566	1,77	5,38	15,3	36,3	64,3	85,1
30	0,080	0,254	0,799	2,48	7,46	20,3	44,6	71,8	87,0

T°C ↓

Non toxic

Toxic



Source: Emerson, K., R.E. Lund, R.V. Thurston and R.C. Russo. 1975. Aqueous ammonia equilibrium calculations: effect of pH and temperature. J. Fish. Res. Board Can. 32: 2379-2383.

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SAGR

Submerged Attached Growth Reactor

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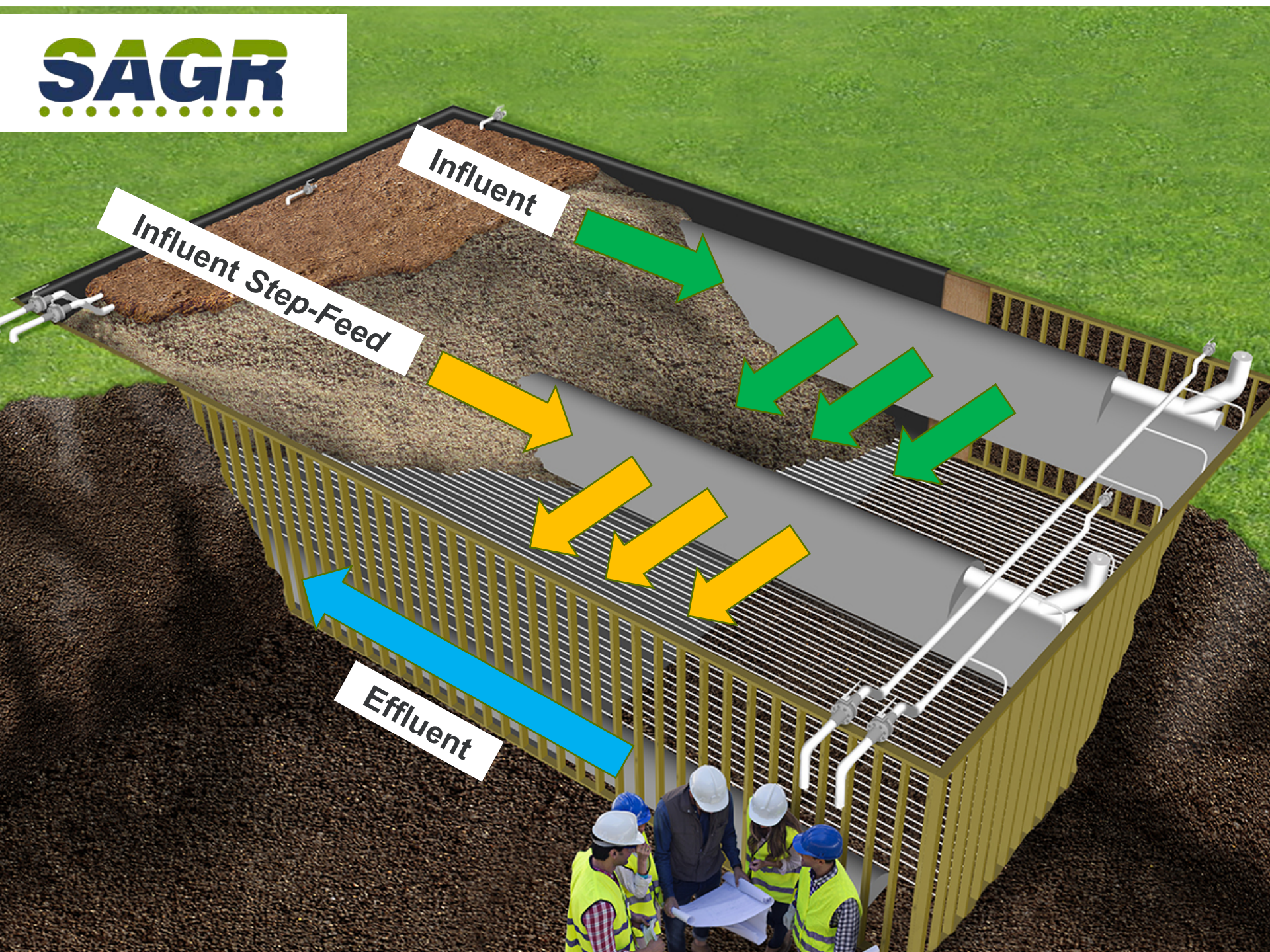
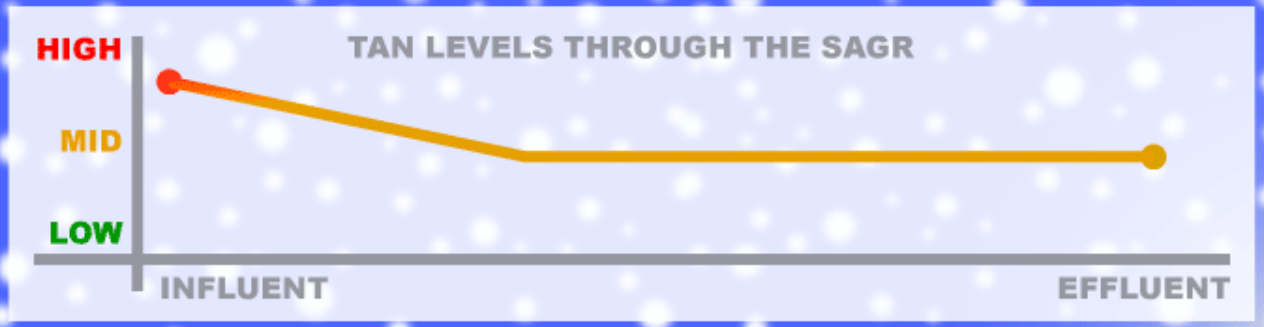
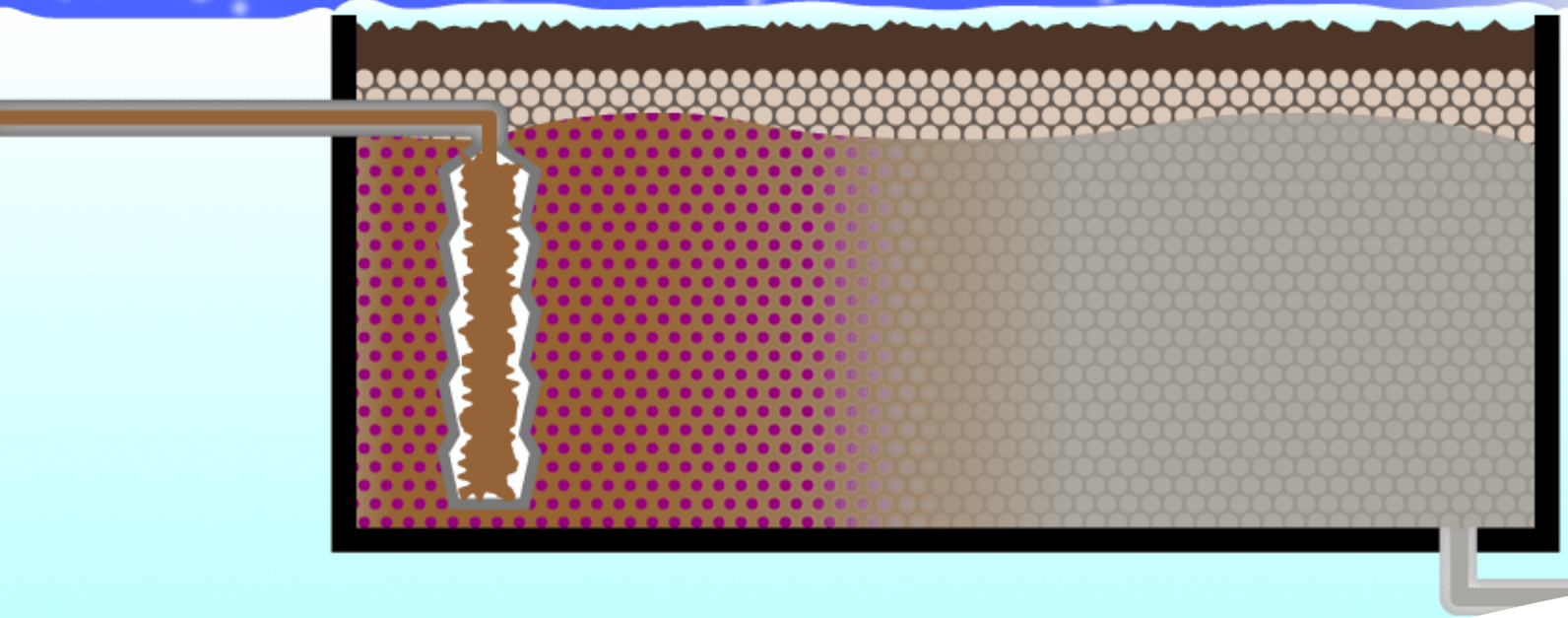

SAGR
Influent
Influent Step-Feed
Effluent

Without Step-Feed: Winter





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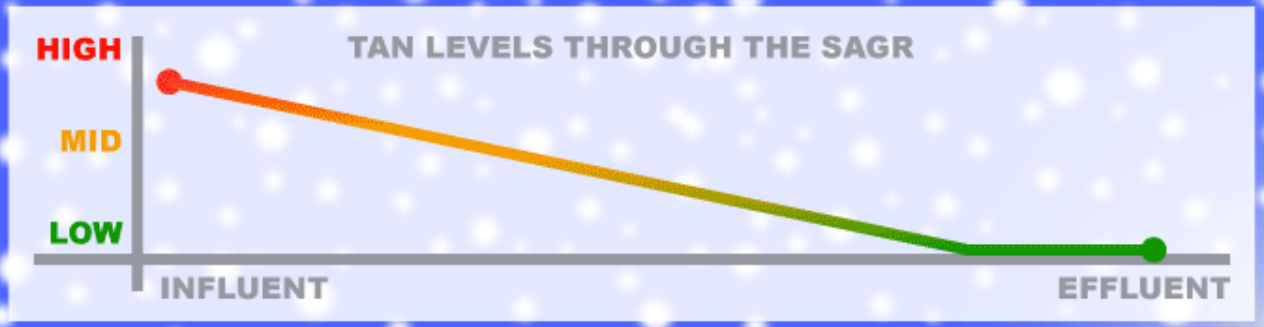
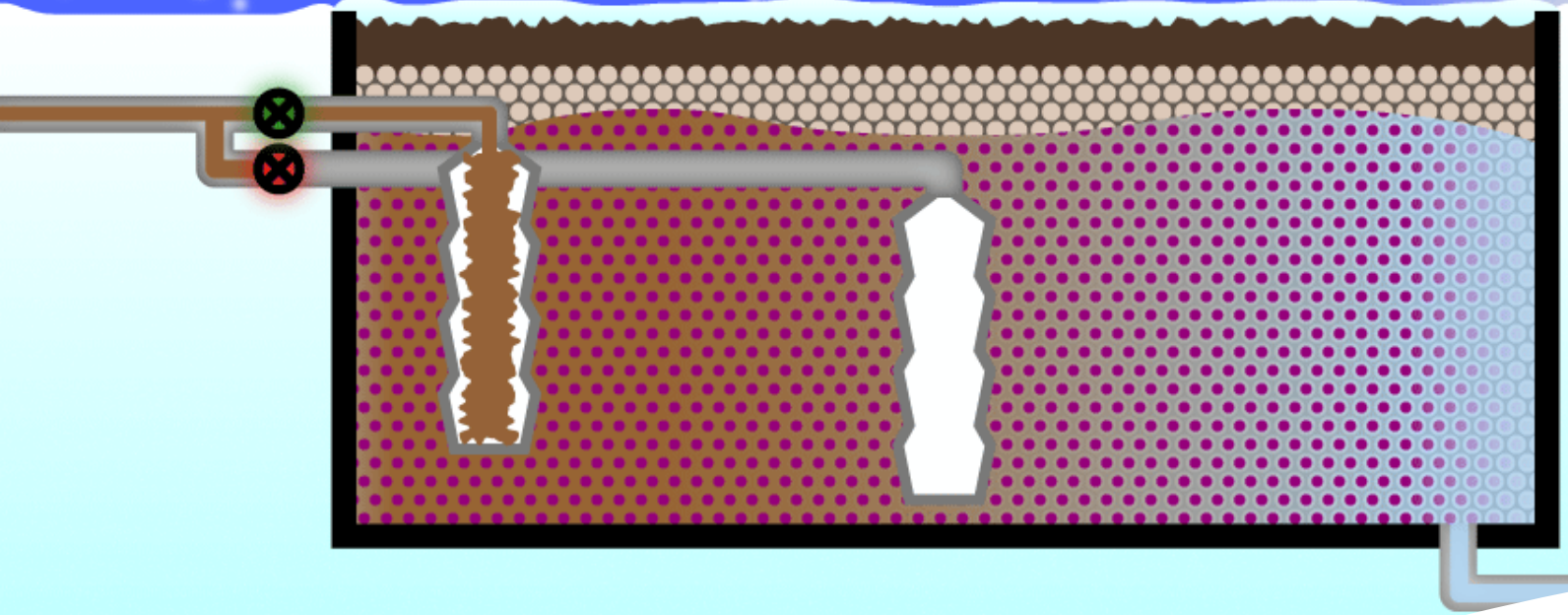
With Step-Feed: Winter





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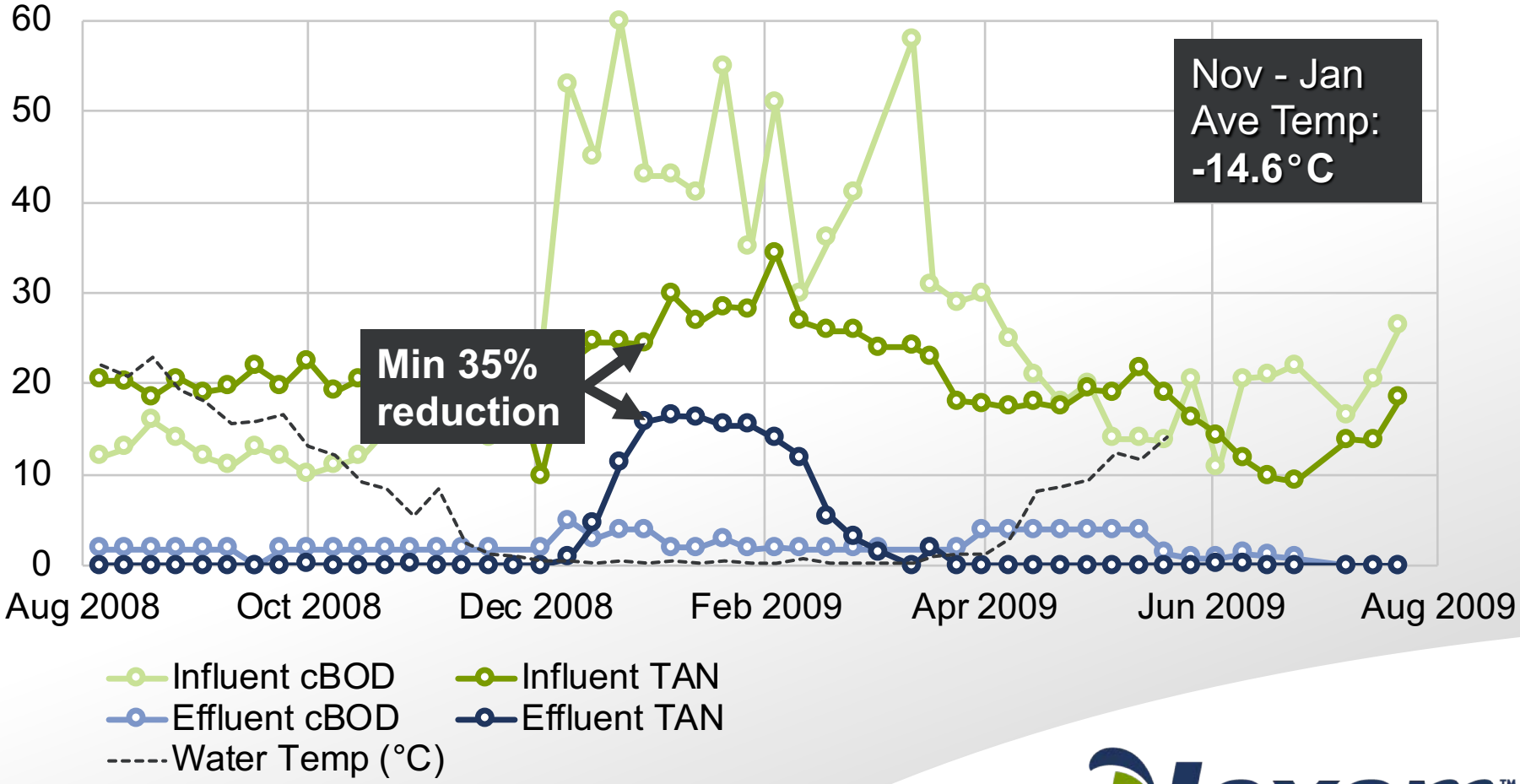
Demonstration Unit
Steinbach, Manitoba (2007-2010)

SAGR Control

SAGR Step-Feed

SAGR®

Control



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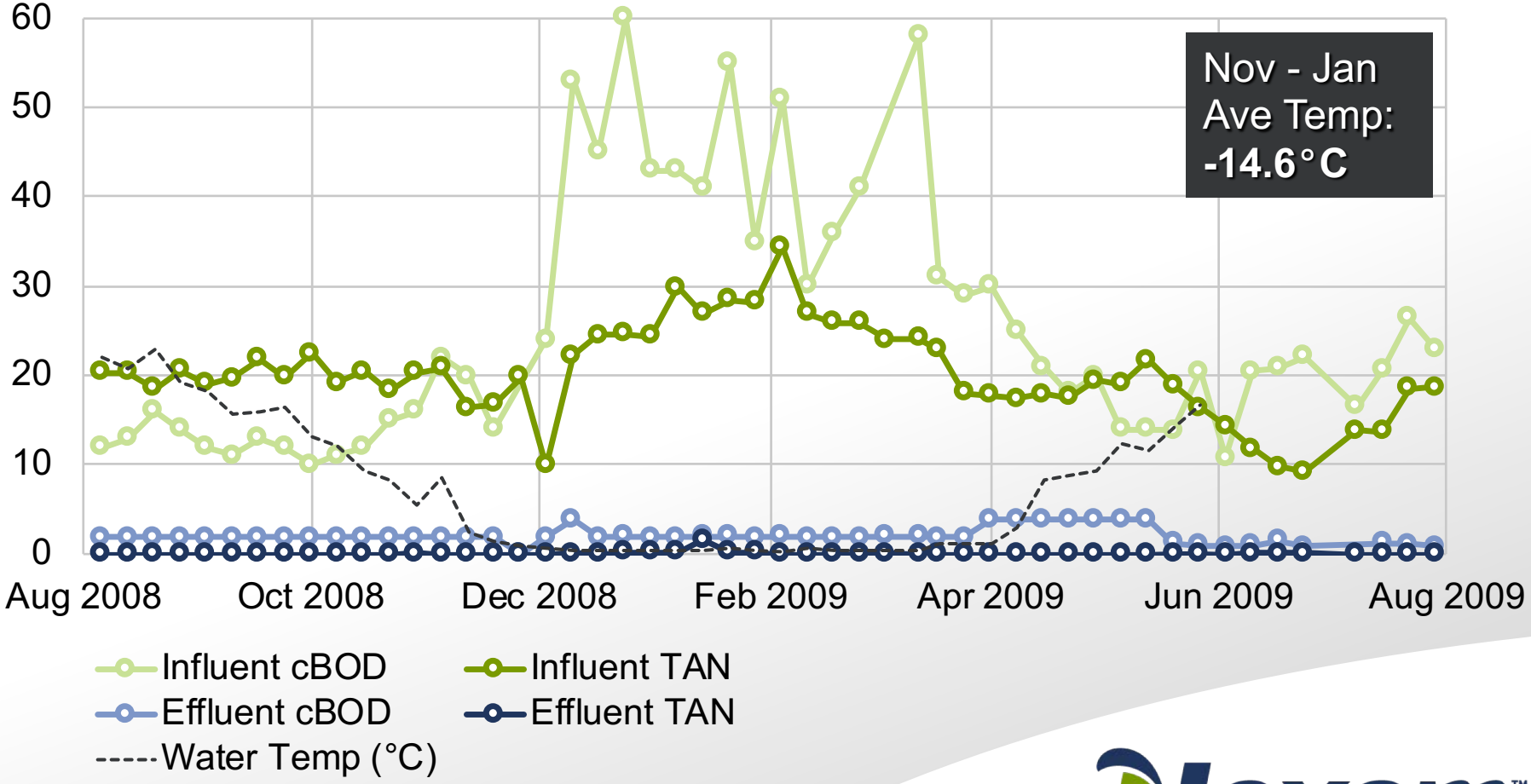
SAGR®

Step-Feed



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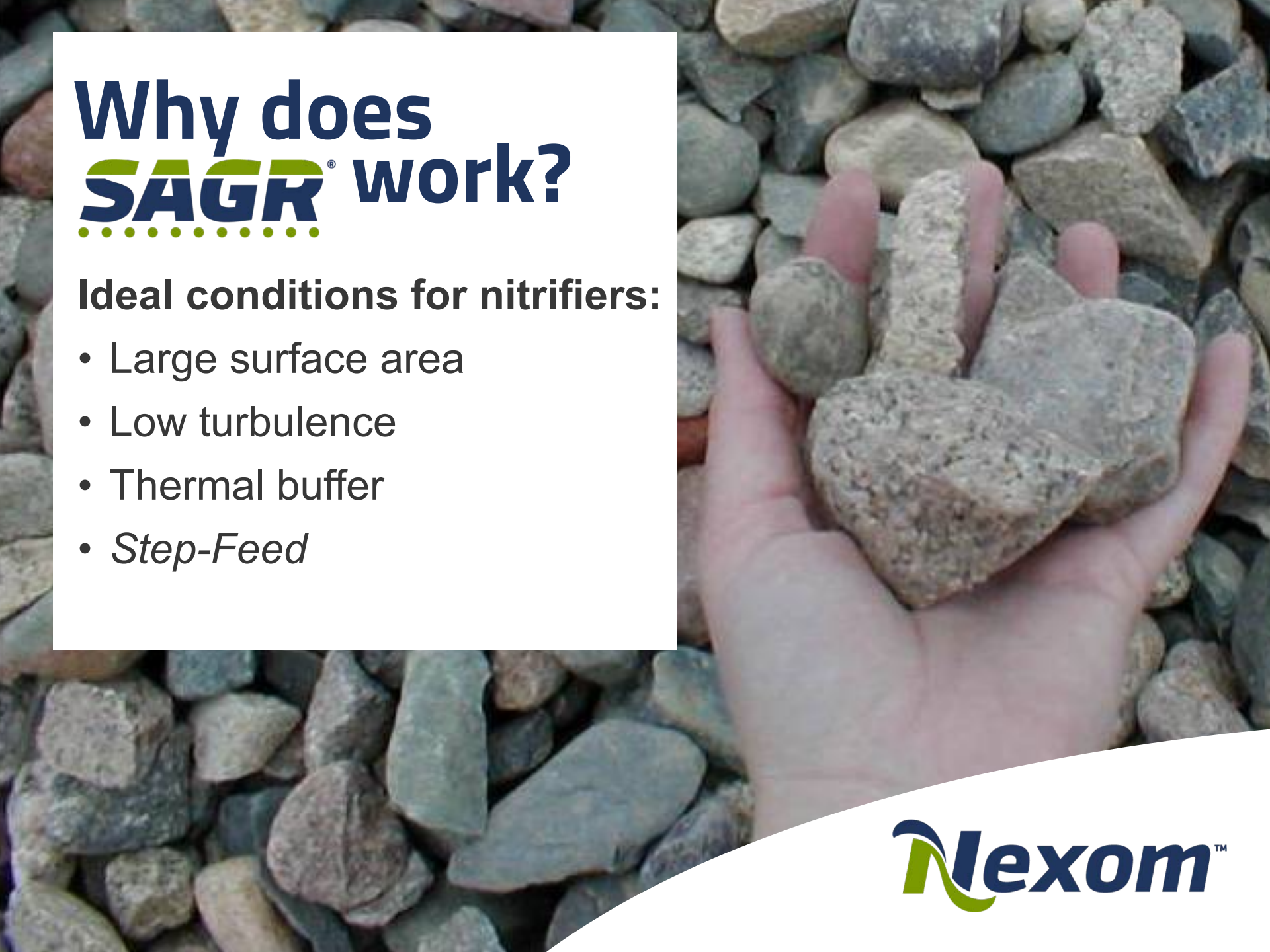

Why does SAGR® work?

Ideal conditions for nitrifiers:

- Large surface area
- Low turbulence
- Thermal buffer
- *Step-Feed*

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SAGR®

- Black River FN
- Bloodvein FN
- Chemawawin Cree Nation
- Driftpile First Nation
- Eabametoong
- Hollow Water FN
- Indian Birch
- Kinonjeoshtegon FN (Jackhead 43)
- Lake Manitoba FN
- Lake St Martin
- Little Grand Rapids
- Little Saskatchewan FN
- Long Plain FN
- M'Chigeeng
- Misipatawistik CN
- Nelson House CN
- Nigigoonsiminikaaning
- Northlands FN
- Opaskwayak Cree Nation
- Pauingassi FN
- Peguis
- Samson Cree Nation
- Sandy Bay
- Sapotaweyak
- Shamattawa
- Tsi Snaihne (Akwesasne)
- War Lake

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Long Plain First Nation, MB

Design Flow:
1000 m^3/d

Effluent Objectives:
BOD : <10 mg/L
TSS : <10 mg/L
TP : <1 mg/L
TAN : <1/5 mg/L
(summer/winter)

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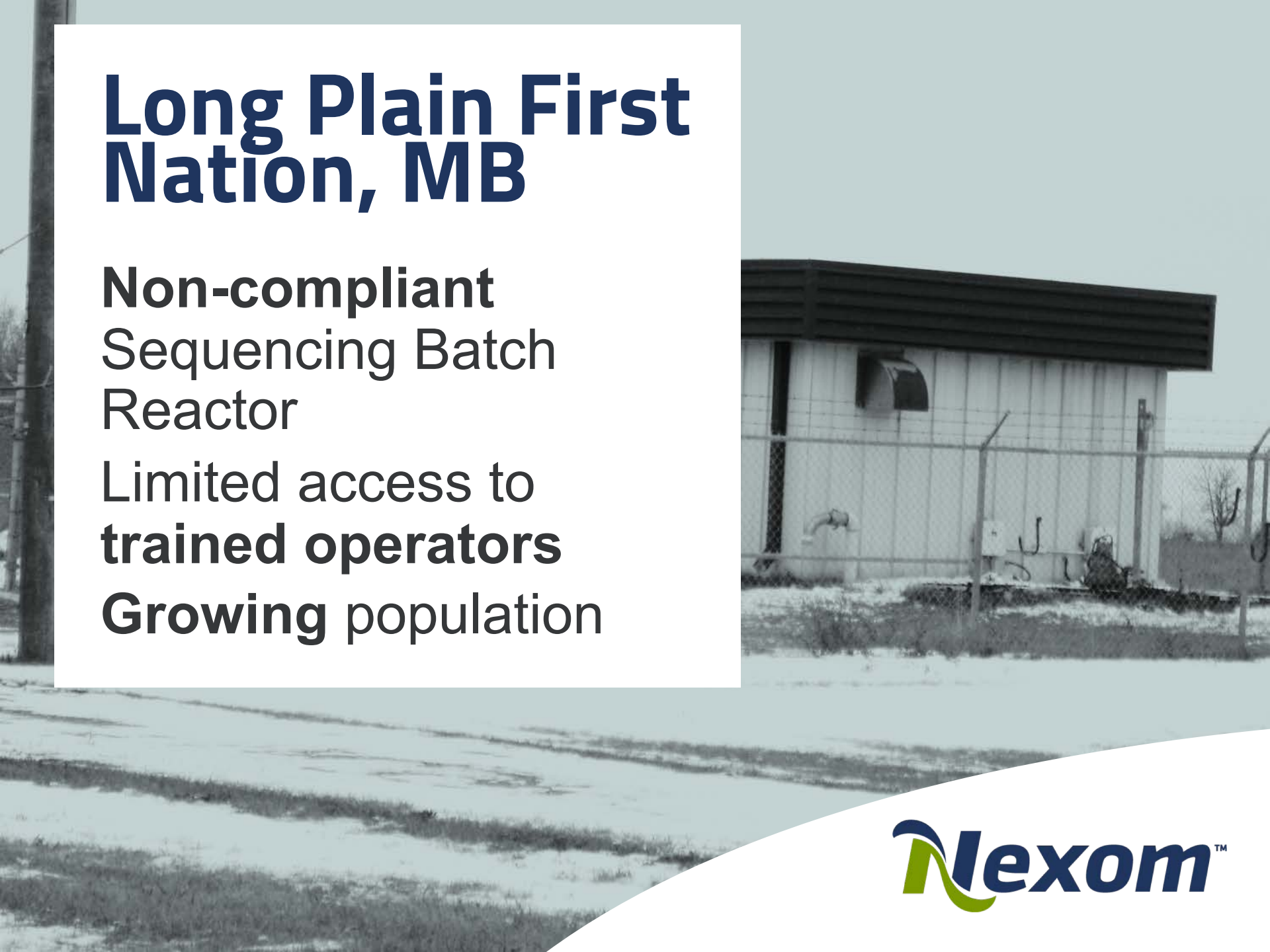
Long Plain First Nation, MB

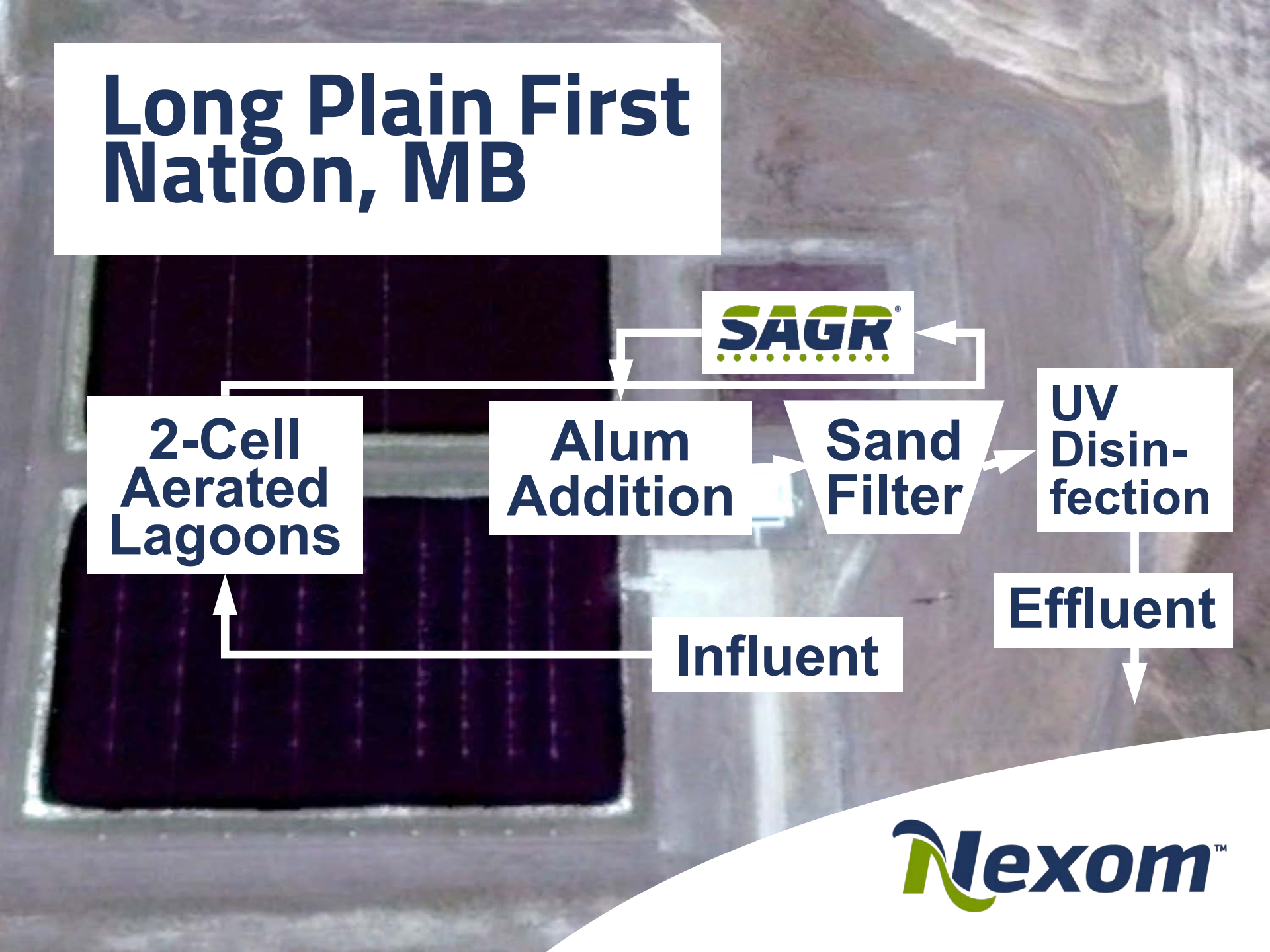
Non-compliant Sequencing Batch Reactor

Limited access to **trained operators**

Growing population



Long Plain First Nation, MB



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Long Plain First Nation, MB

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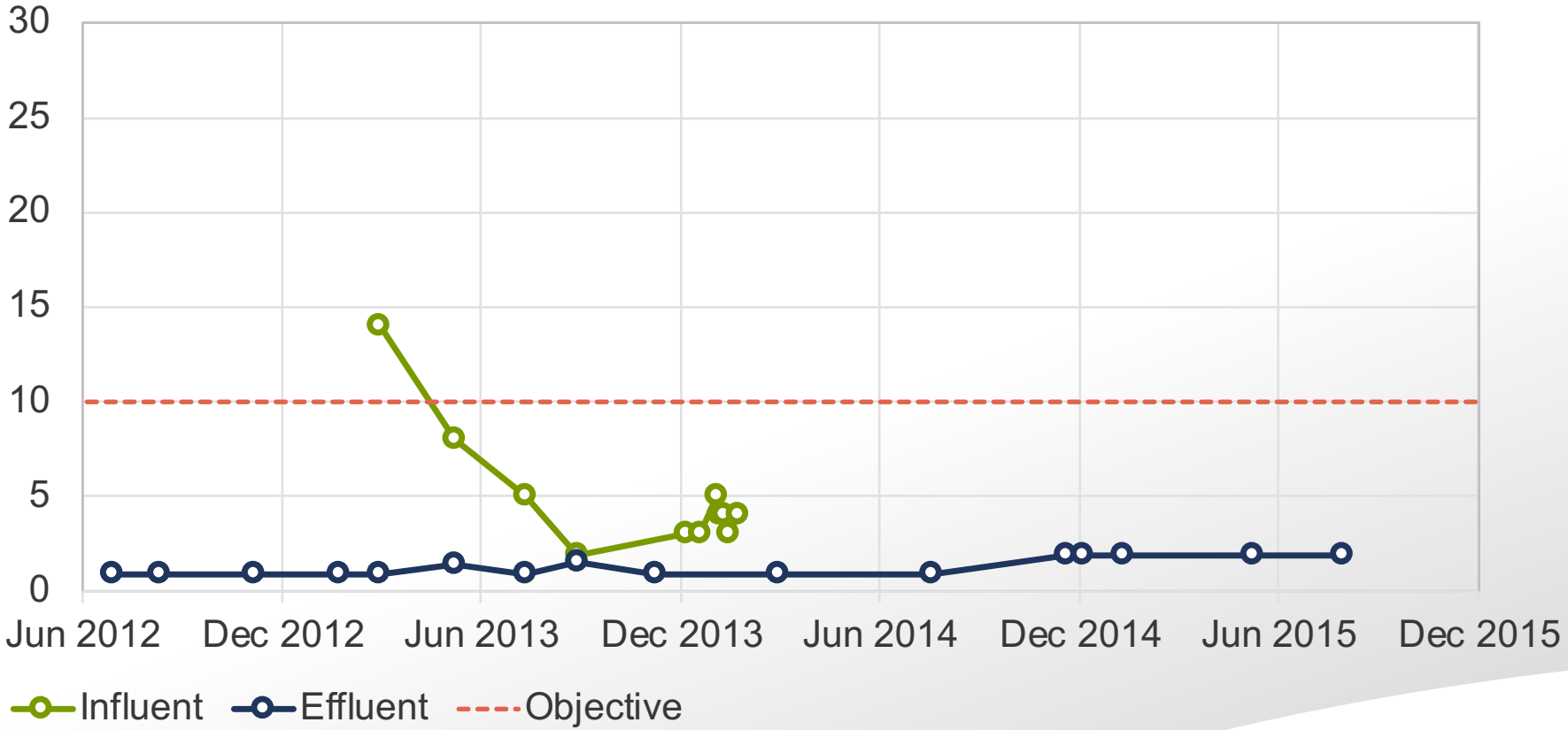
Long Plain First Nation, MB SAGR® $cBOD_5$ (mg/L)



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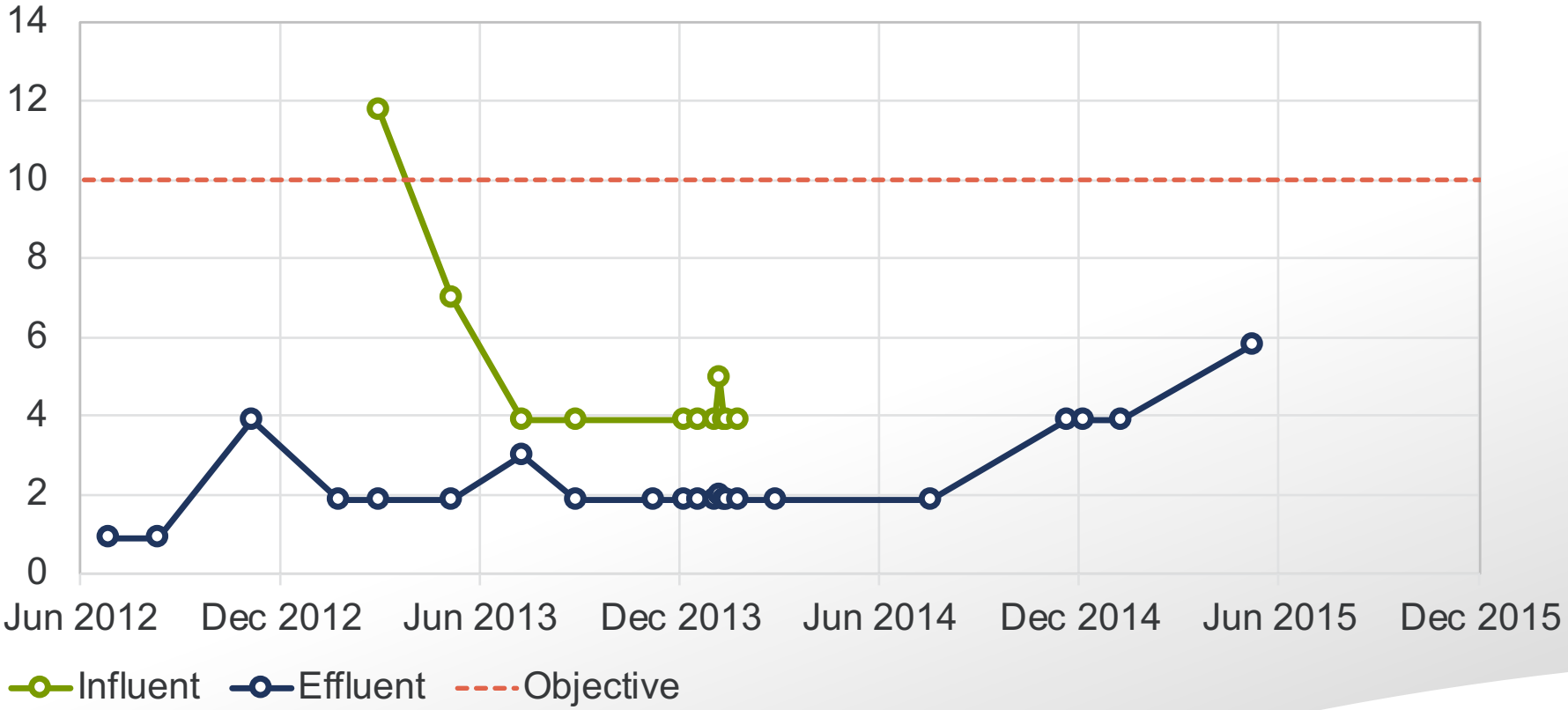
Long Plain First Nation, MB SAGR® TSS (mg/L)



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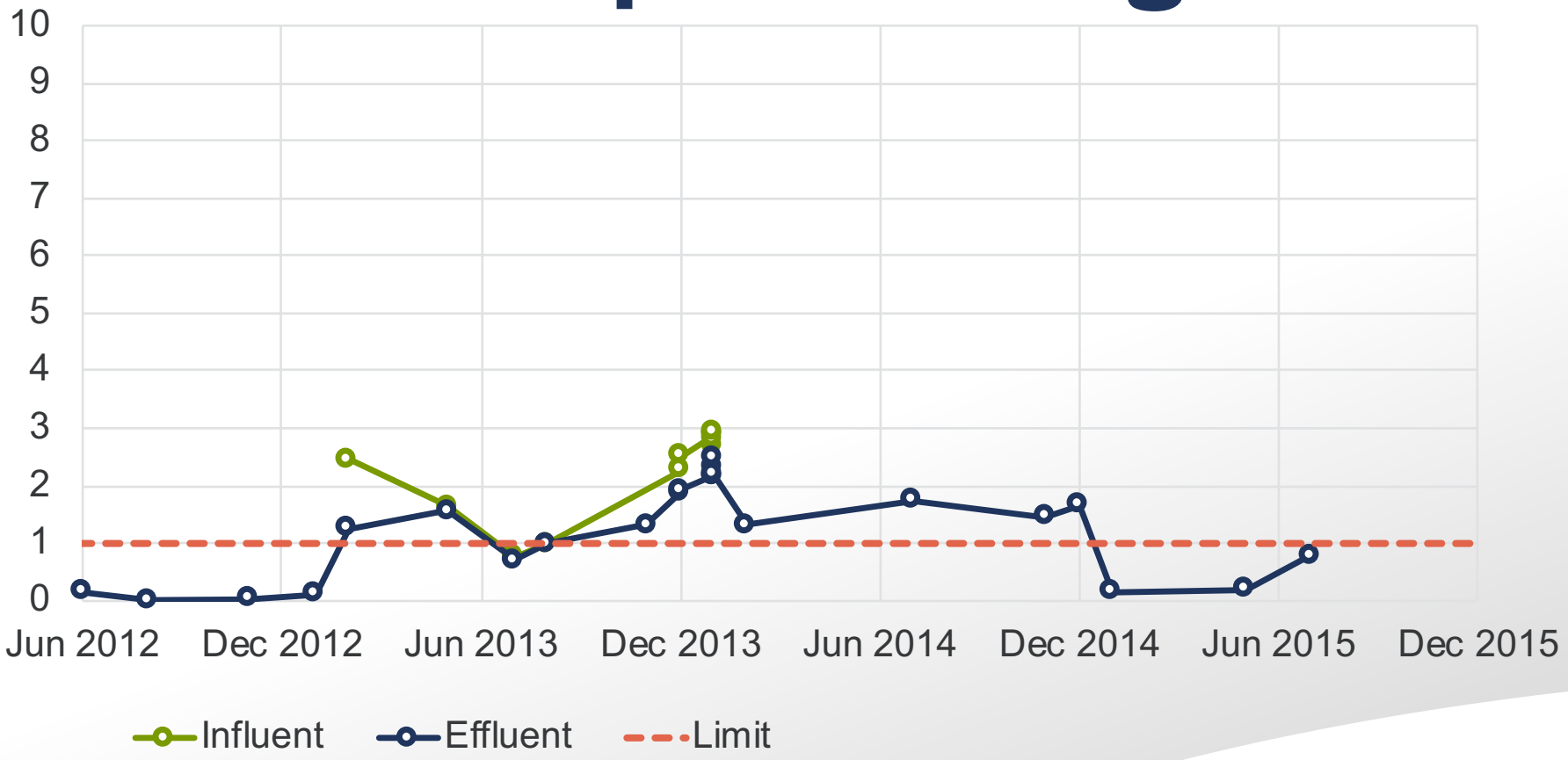
Long Plain First Nation, MB
Total Phosphorus (mg/L)



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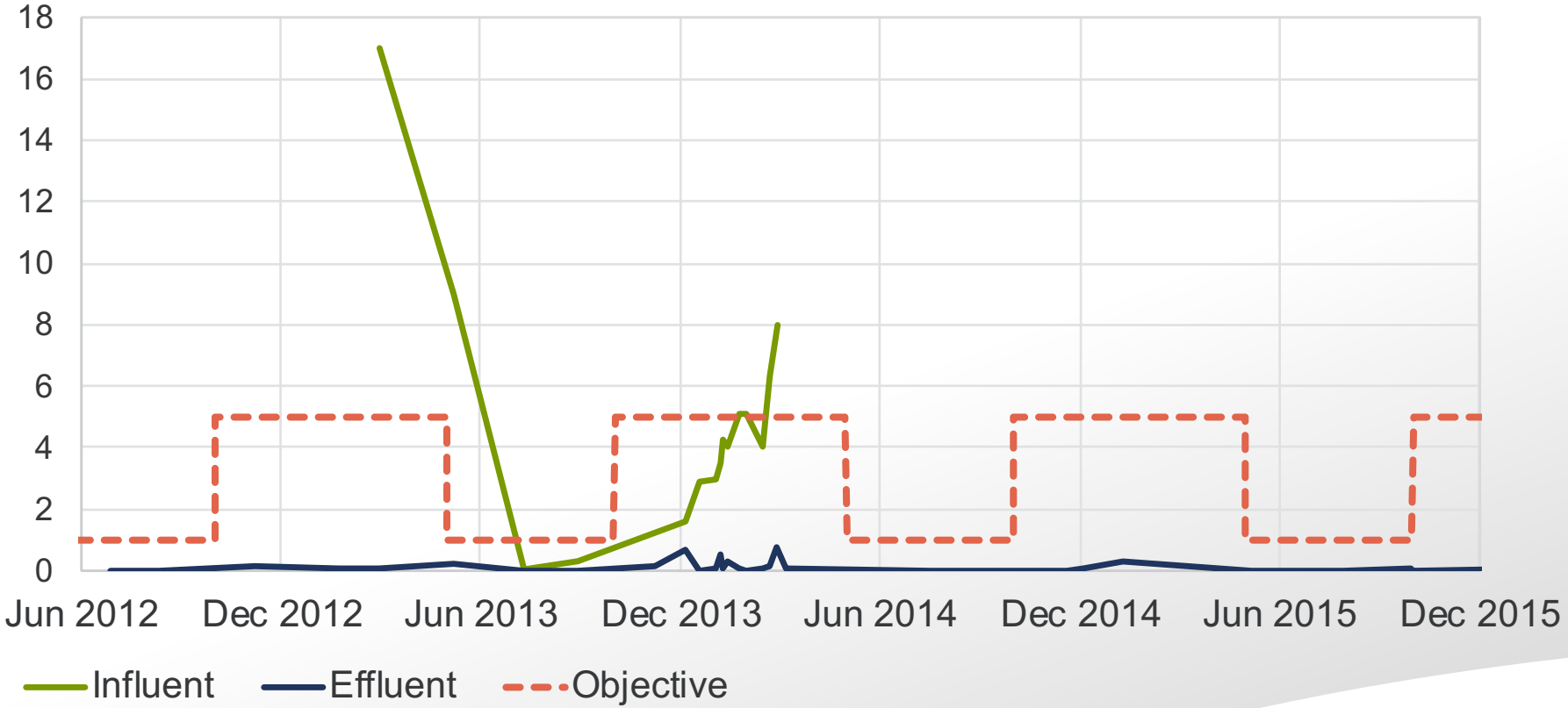
Long Plain First Nation, MB SAGR® TAN (mg/L)



Misipawistik Cree Nation

Design Flow:
400 m^3/d

Effluent Objectives:
BOD : <20 mg/L
TSS : <25 mg/L
TP : <1 mg/L
TAN : <1/7 mg/L
(summer/winter)
Non-Toxic

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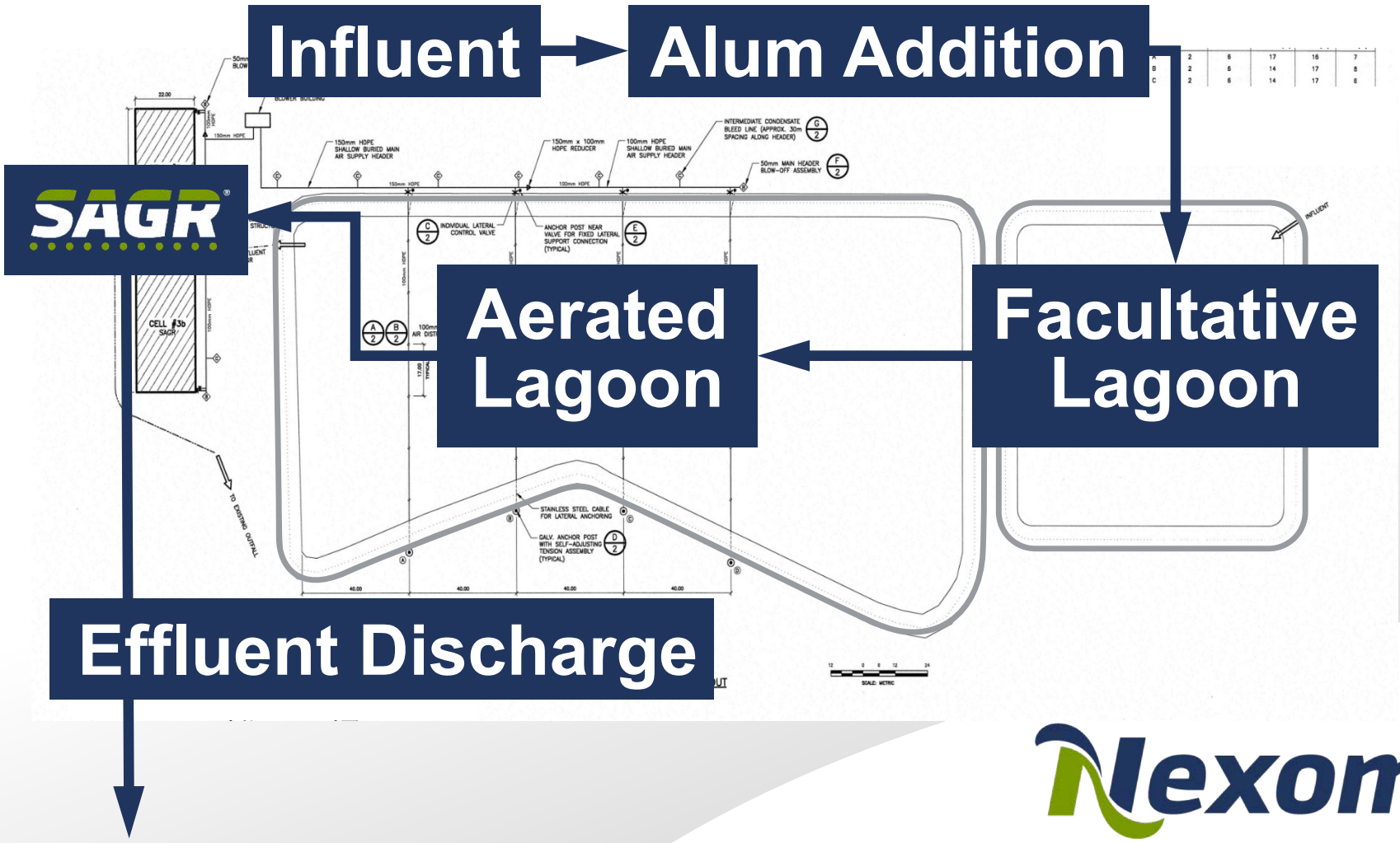
Misipawistik Cree Nation, MB



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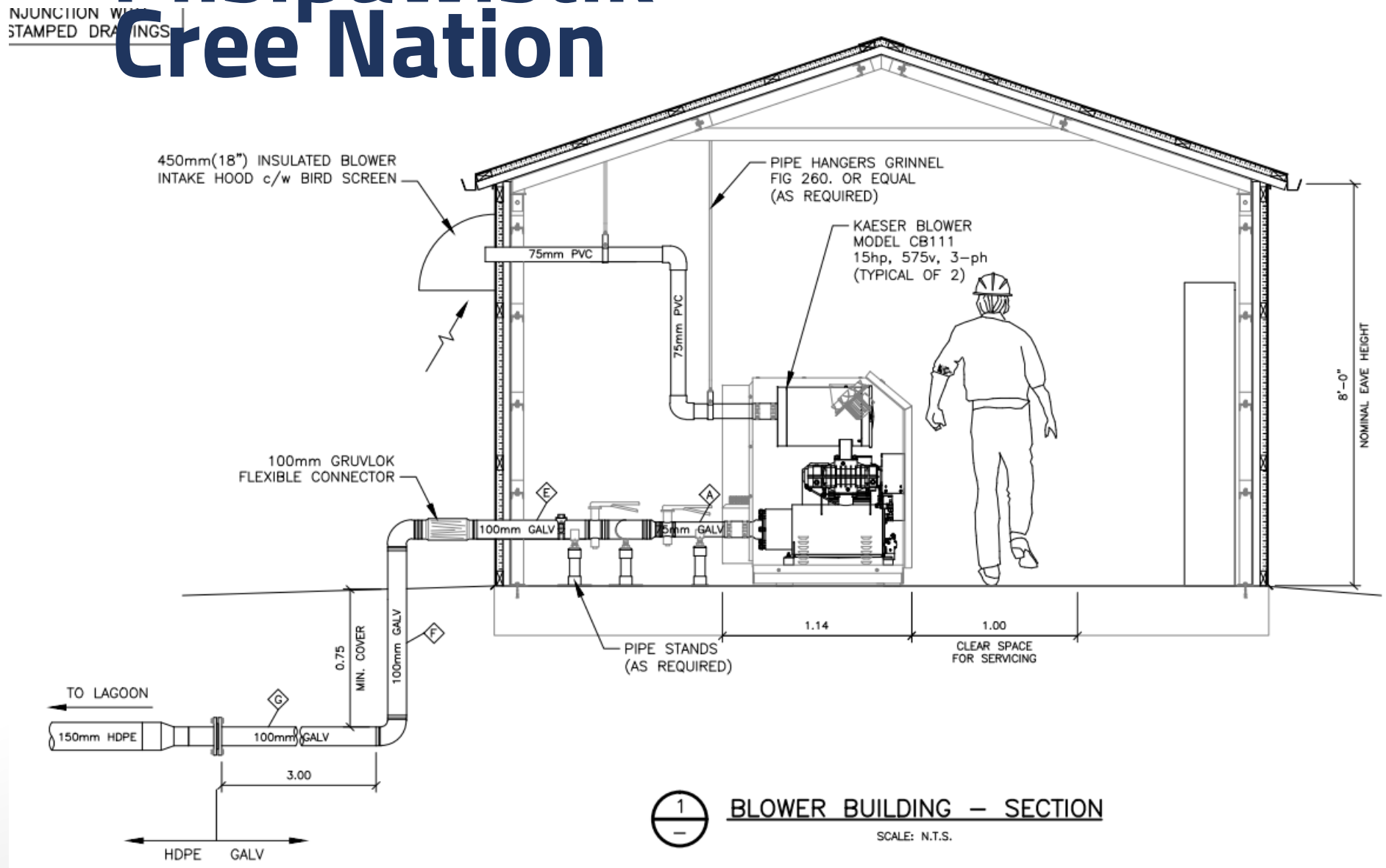
Misipawistik Cree Nation

Nexom™

Misipawistik Cree Nation

Nexom™

Misipawistik Cree Nation

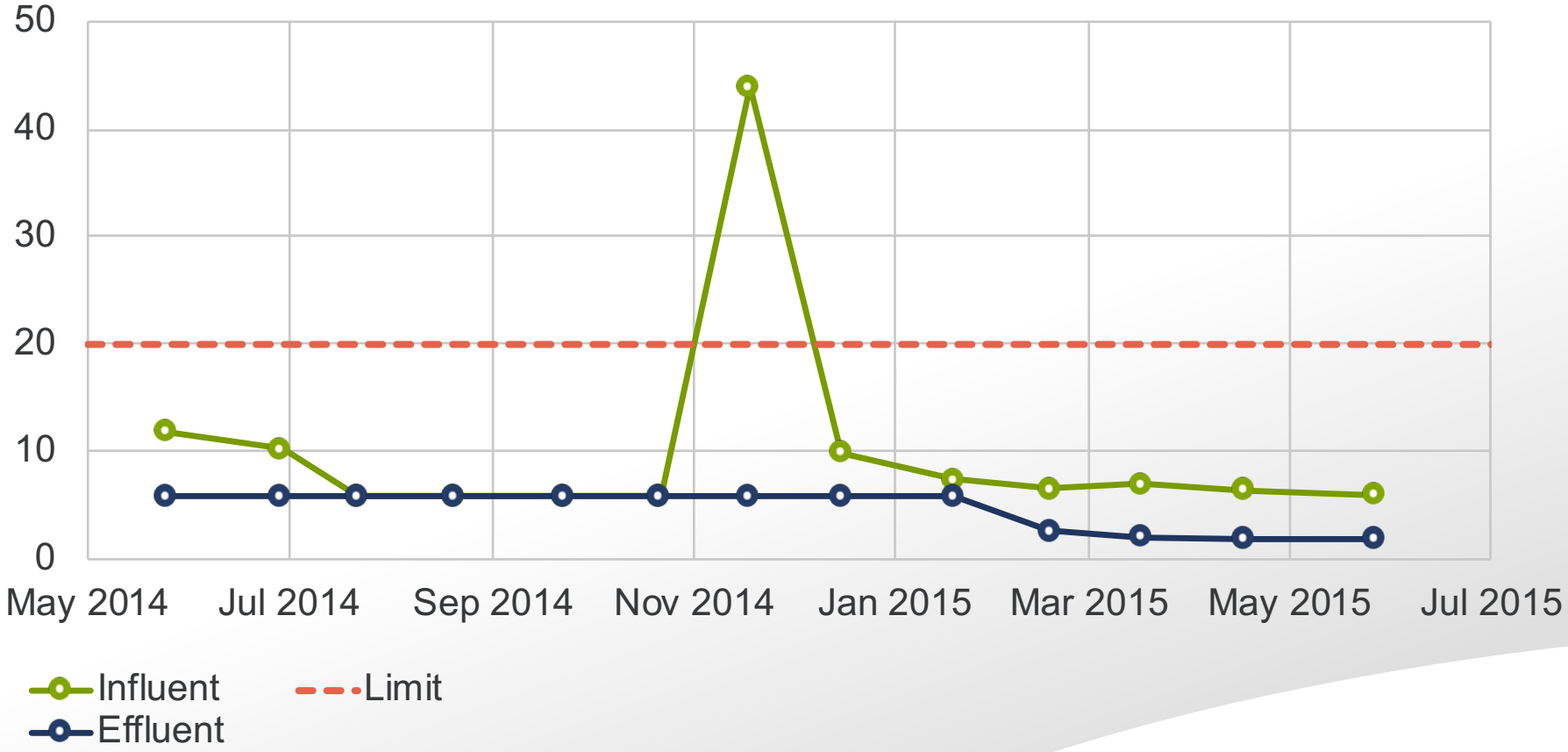


1 — BLOWER BUILDING – SECTION

SCALE: N.T.S.

Misipawistik Cree Nation

SAGR® $cBOD_5$ (mg/L)



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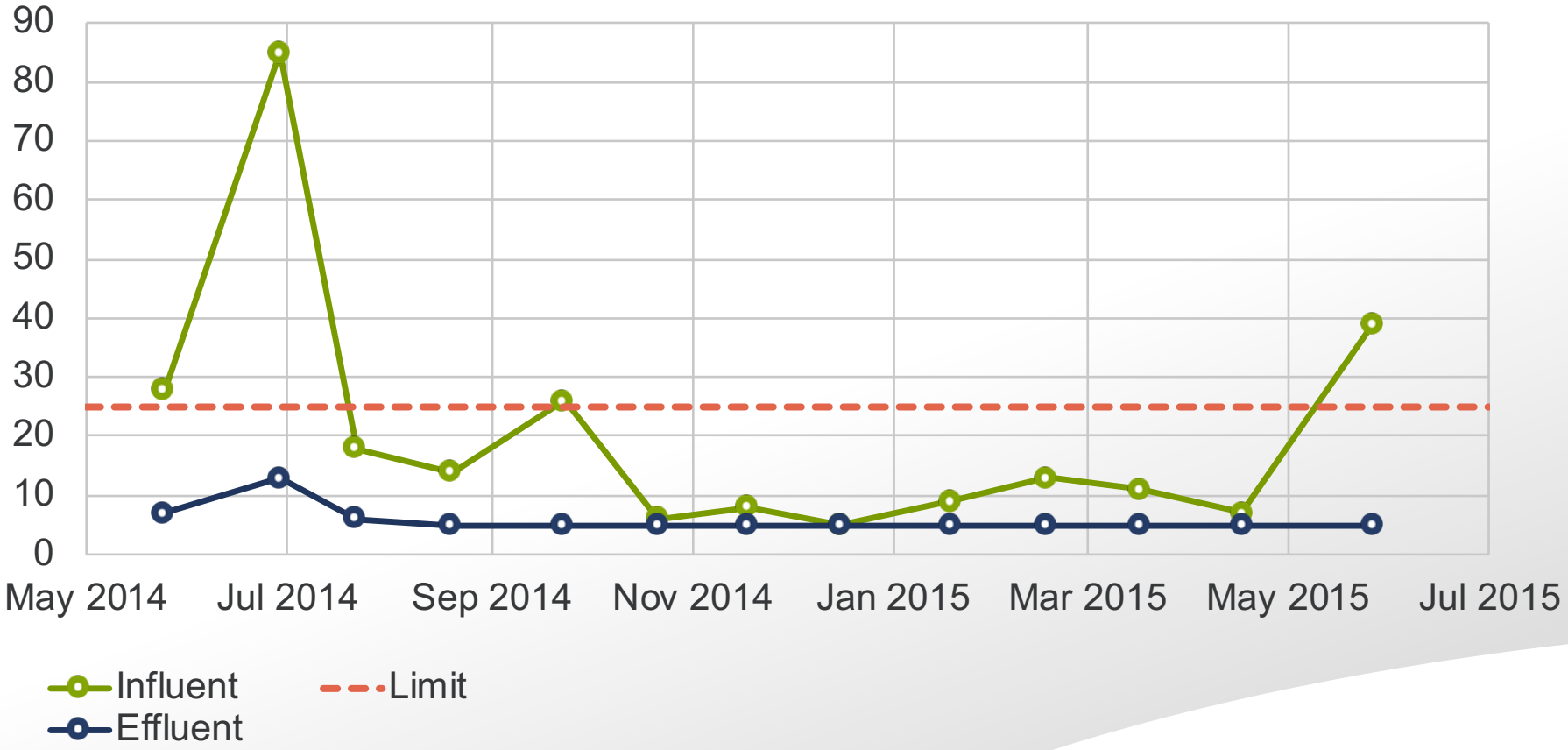
Misipawistik Cree Nation

SAGR® TSS (mg/L)



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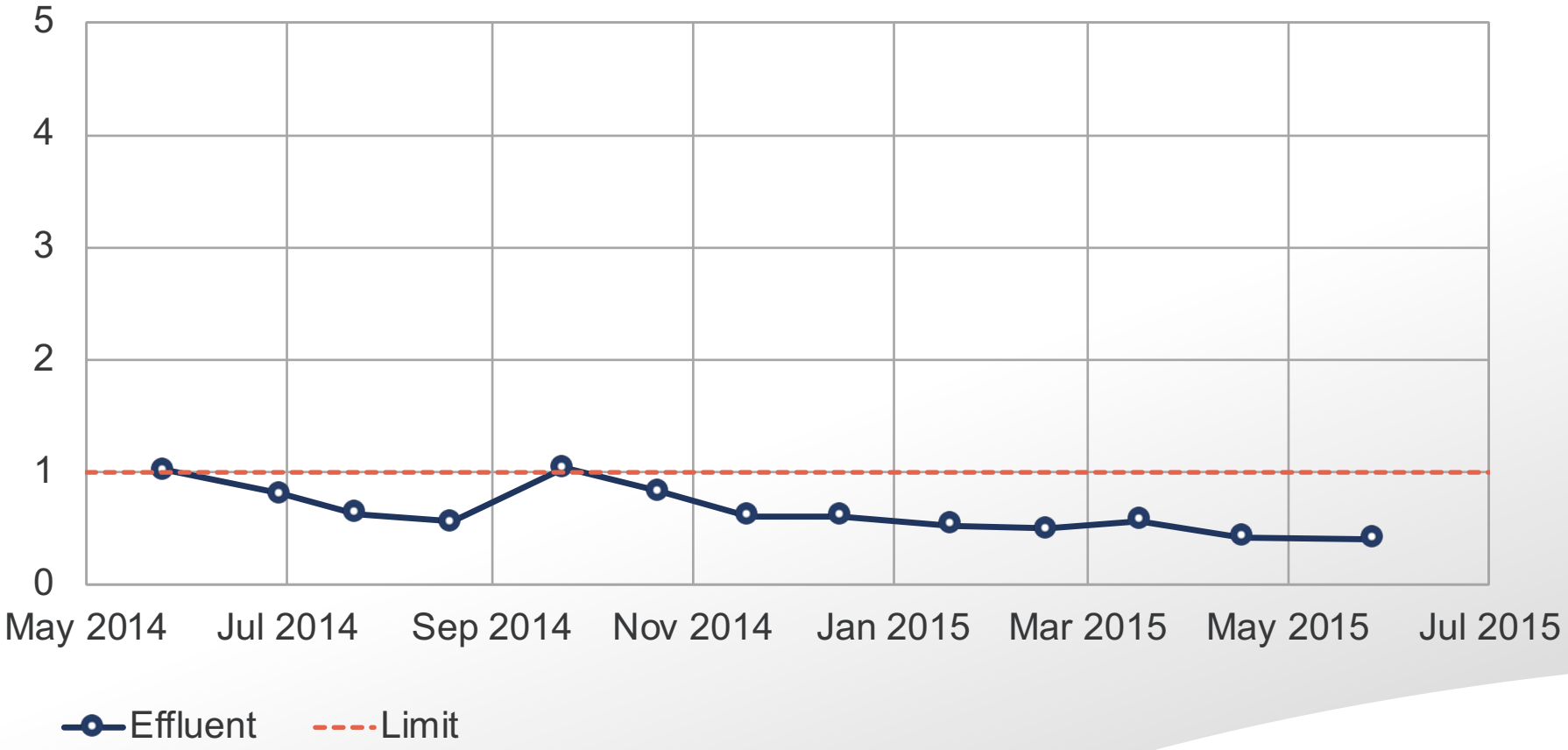
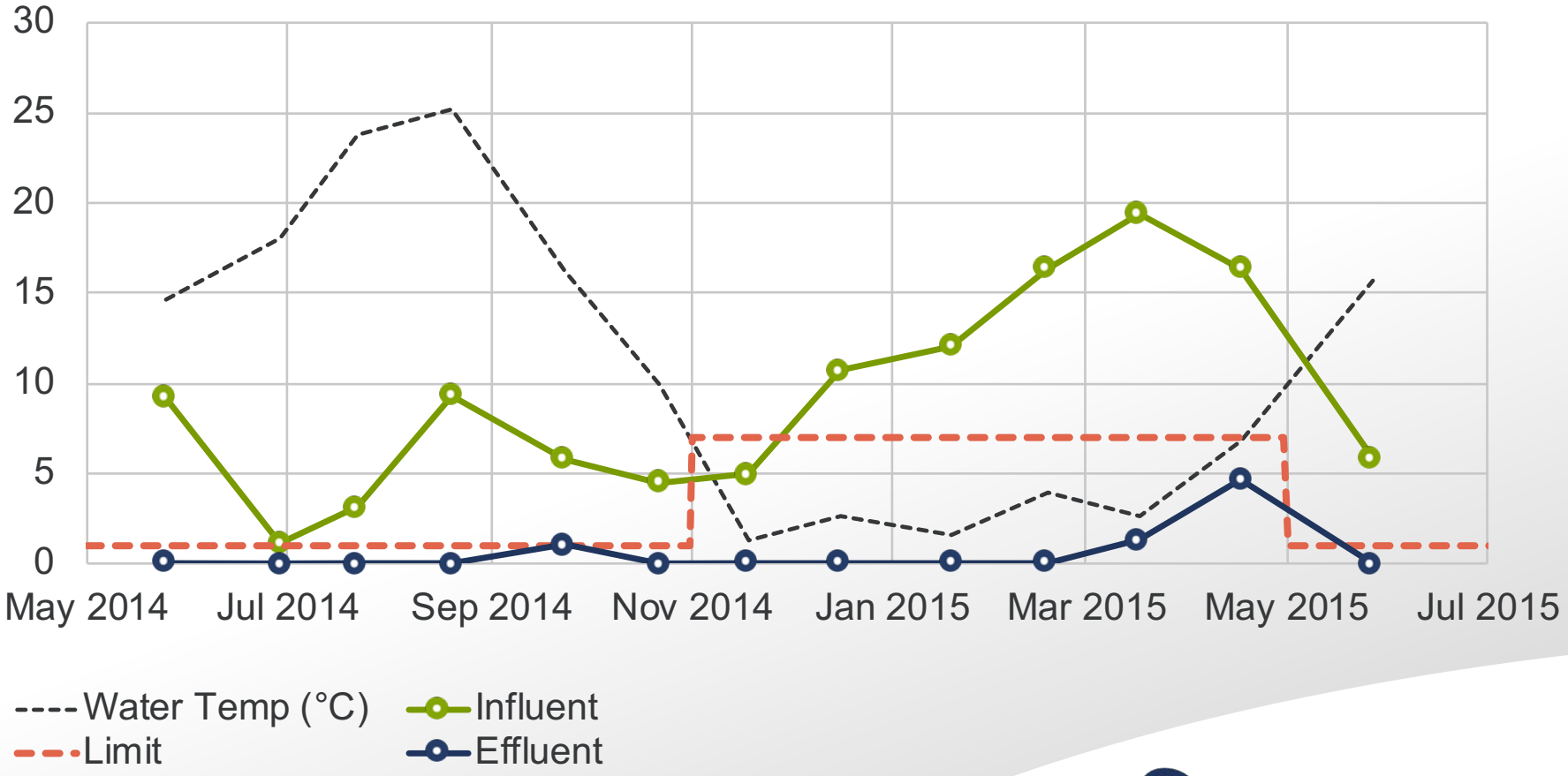
Misipawistik Cree Nation Total Phosphorus (mg/L)



Misipawistik Cree Nation

SAGR® TAN (mg/L)



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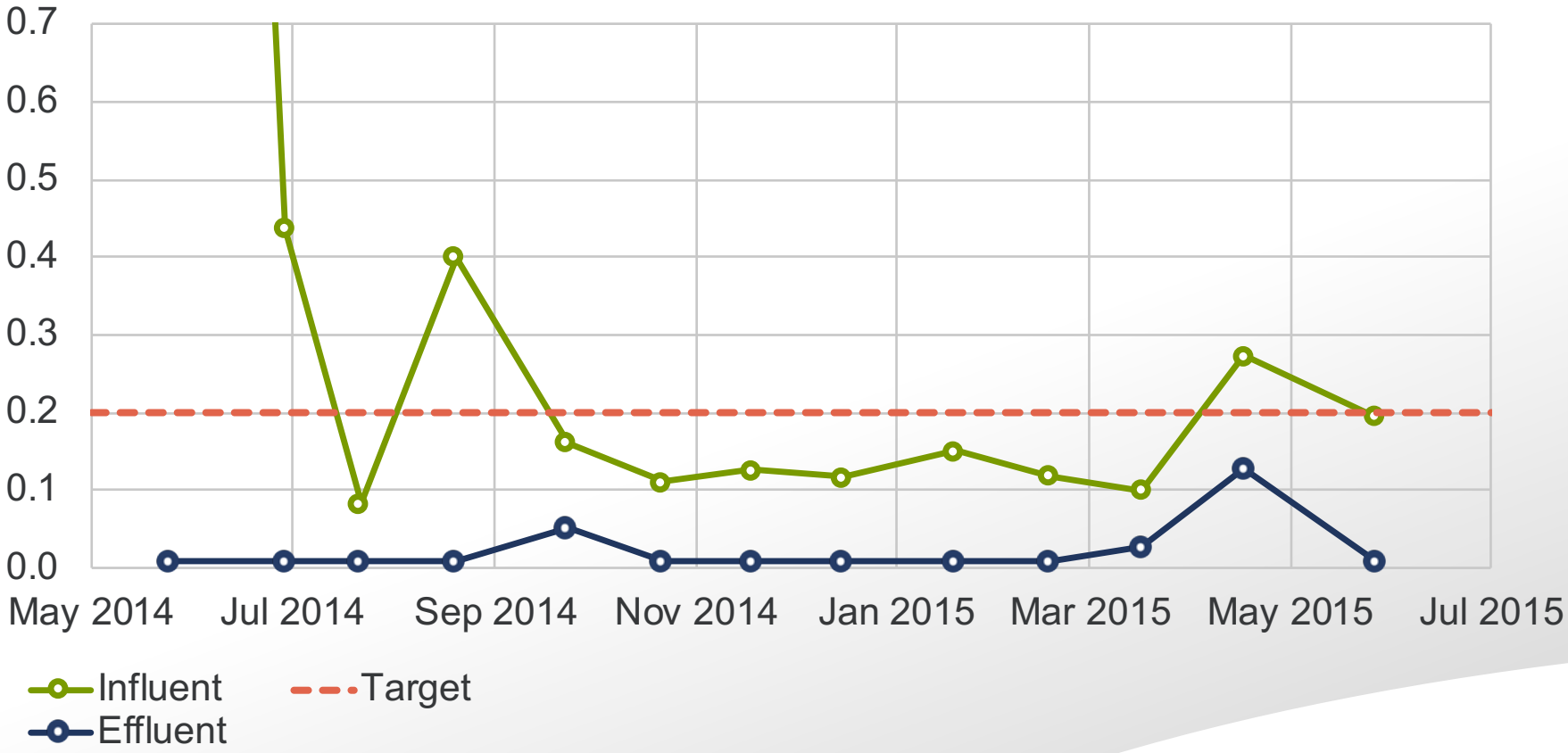
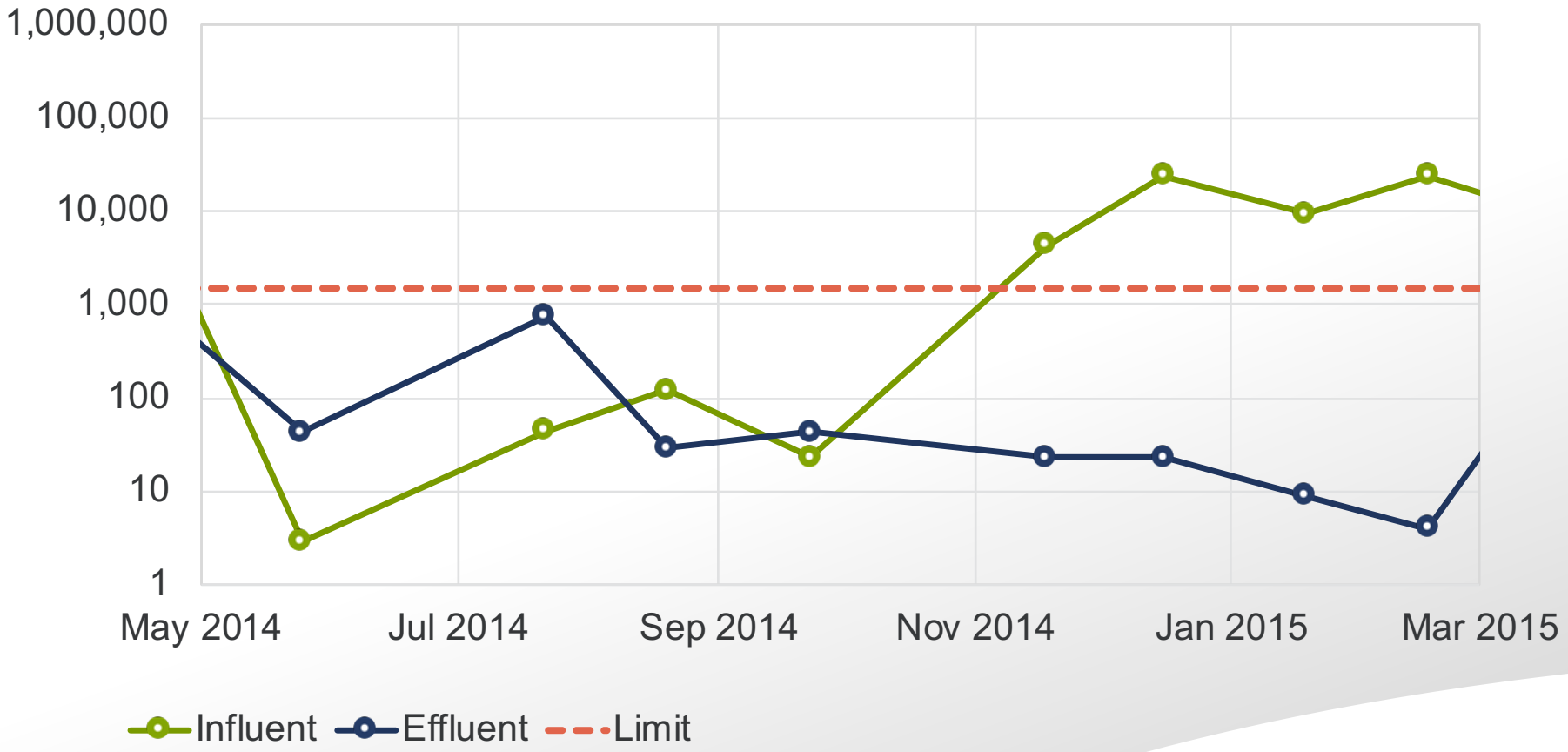
Misipawistik Cree Nation
SAGR® Un-ionized Ammonia



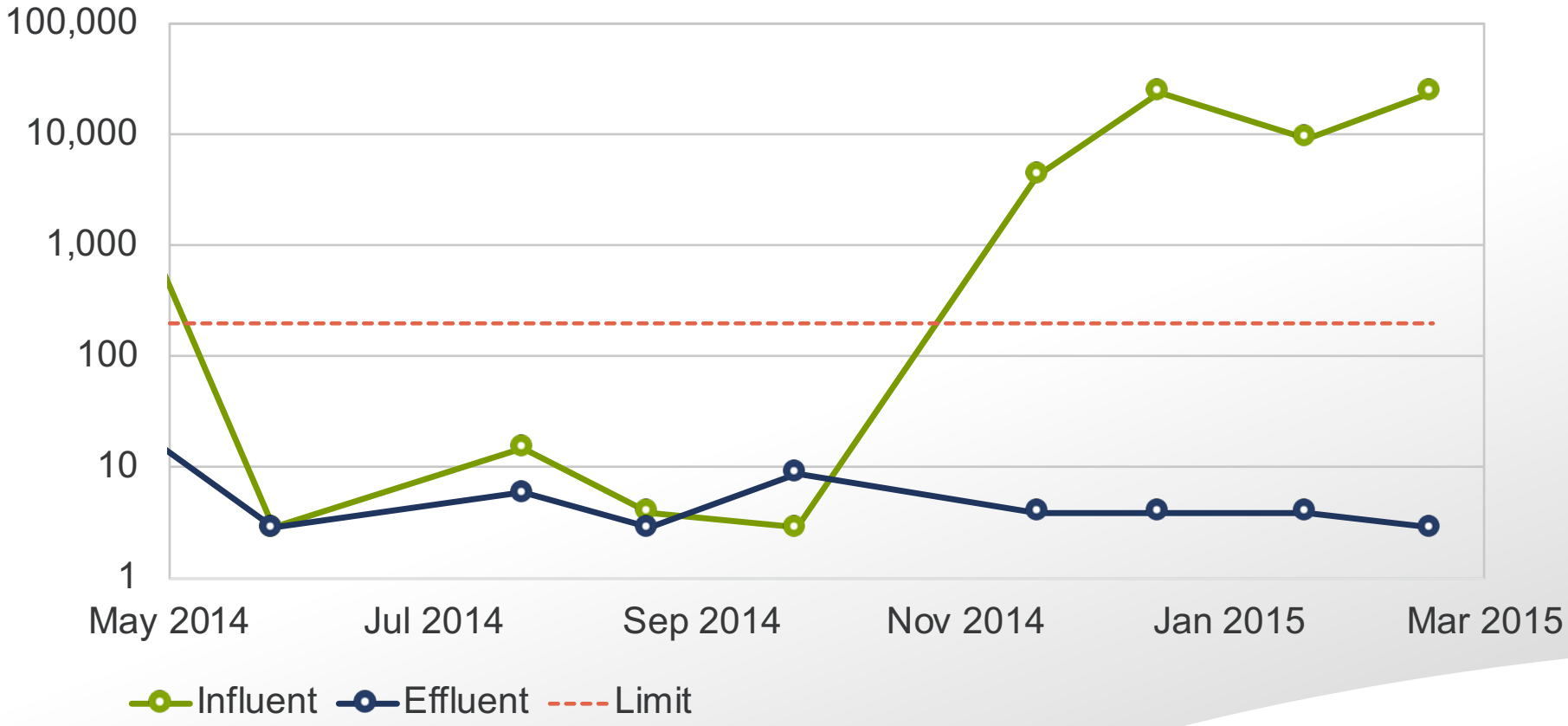
Nexom™

Misipawistik SAGR® Total Coliform (MPN/100mL)



Nexom™

Misipawistik SAGR® Fecal Coliform (MPN/100mL)



Nexom™

Ongoing research

Pharmaceuticals reduction

Lagoon and SAGR system

- 17-Ethynylestradiol
- 2,4-Dichlorophenoxyacetic acid
- Carbamazepine
- Clarithromycine
- Diazinon
- Diclofenac
- Ibuprofen
- Metoprolol
- Naproxen
- Sulfamethoxazole
- Trimethoprim

Indigenous Services Canada

THE UNIVERSITY OF WINNIPEG

RED RIVER COLLEGE
OF APPLIED ARTS, SCIENCE AND TECHNOLOGY

UNIVERSITY OF MANITOBA

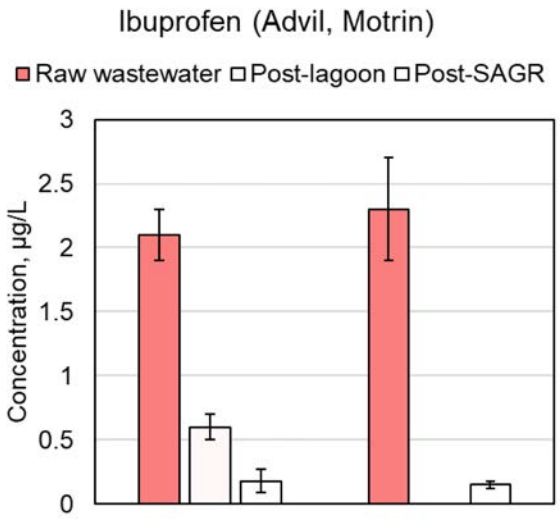
Misipawistik Cree Nation

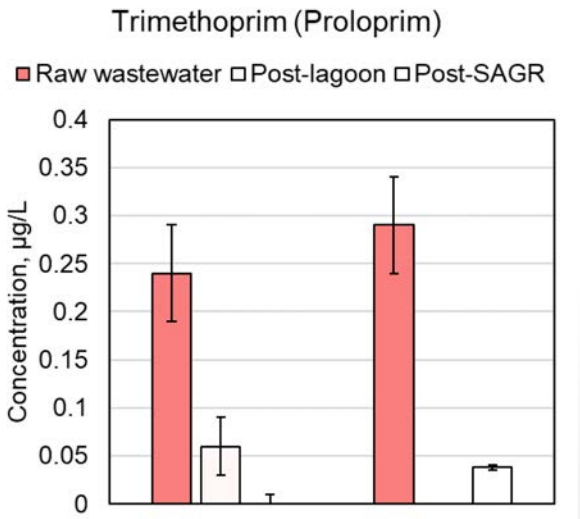
LONG PLAIN FIRST NATION
TREATY #1 | 1871

Nexom™
technologies for cleaner water

Pharmaceuticals reduction

Lagoon and SAGR system





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Conclusions

- **Lagoons** can offer the **best performance-to-cost** ratio of all treatment technologies
- **Lagoons with SAGR** provide **complete nitrification** (< 1 mg/L) **year round** (< 1°C)
- **Compliance** with federal regulations (25/25/non lethal)
- **Polishing** of suspended solids (< 10 mg/L) w/o clarifier, DAF or filter
- **Disinfection** (< 200 UFC/100mL) without UV
- **Pharmaceuticals**

Nexom™